COMPARATIVE STUDY OF NUCLEATION PROCESSES FOR THE GROWTH OF NANOCRYSTALLINE DIAMOND

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Abstract

Methods for seeding silicon substrates with explosion produced nanodiamond powder and the in-situ generation of diamond nuclei by the bias enhanced nucleation (BEN) method have been studied to examine their effects on the nucleation density as well as the morphology, the growth rate, and the quality of nanodiamond films. Besides the in-situ BEN process, three ex-situ diamond seeding methods were studied, i.e., (i) mechanical abrasion by diamond powder, and ultrasonication of silicon, (ii) with and (iii) without pre-treatment of the silicon substrate by a hydrocarbon plasma, in solvents with suspended nanodiamond. Although the growth of nanocrystalline diamond is predominantly controlled by the high secondary nucleation rate that is promoted by the high density C_2 radicals in a noble-gas-rich microwave plasma environment, a higher diamond seeding and nucleation density on the substrate is also found to result in a higher growth rate for nanocrystalline diamond. With an optimized diamond seeding or nucleation process, ultra-thin, smooth and homogenous nanocrystalline diamond films have been fabricated.

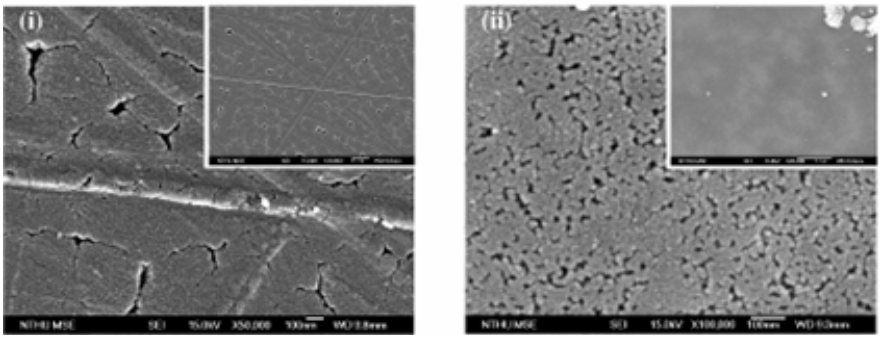

Figure 1- SEM photographs of the nucleation sides of NCD films grown using (i) diamond seeding by mechanical abrasion by diamond powder and (ii) ultrasonication of silicon in a solvent with nanodiamond powder. Silicon was pre-treated by a hydrocarbon microwave plasma.

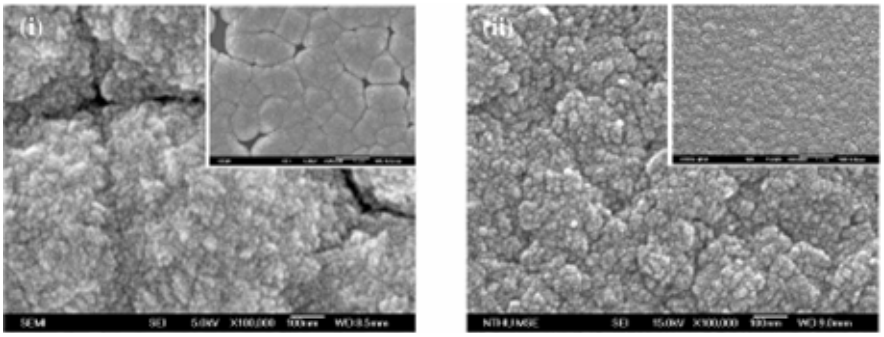

Figure 2- Morphologies of the growth surfaces of nanodiamond films that were (i) seeded by diamond by mechanical abrasion using diamond powder (left) and (ii) in-situ nucleated with diamond by means of a bias-enhanced nucleation process (right) (growth conditions: gas flow rates at CH4/Ar/N2=2/90/10sccm, microwave power of 700W, gas pressure at 125 Torr, deposition time for 1 hr.)